USEFULNESS OF TISSUE DOPPLER IMAGING FOR THE DIAGNOSIS OF RIGHT VENTRICULAR MYOCARDIAL INFARCTION AND DETERMINATION OF INFARCT RELATED ARTERY IN ACUTE INFERIOR WALL MYOCARDIAL INFARCTION

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Certificate

This is to certify that **Dr S.S.Khaja Rafeeq**, Post graduate student [2003-2006] in the Department of Cardiology, Government General Hospital Chennai & Madras Medical College, Chennai -03, has done this Dissertation on **“USEFULNESS OF TISSUE DOPPLER IMAGING FOR THE DIAGNOSIS OF RIGHT VENTRICULAR MYOCARDIAL INFARCTION AND DETERMINATION OF INFARCT RELATED ARTERY IN ACUTE INFERIOR WALL MYOCARDIAL INFARCTION”** under my guidance and supervision in partial fulfillment of the regulations laid down by The Tamil Nadu Dr M.G.R Medical University, Chennai, for DM Cardiology –Branch II examination to be held in February 2006.

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CONTENTS

INTRODUCTION

In approximately half of patients with inferior wall myocardial infarction, right ventricular myocardial infarction (RVMI) develops[1,2] In patients with RVMI, the risk of death in the hospital is high and major complications are greater. For early diagnosis, electrocardiography and two dimensional echocardiography are used, but these methods are occasionally insufficient.

Tissue Doppler imaging (TDI) has evolved as a new technique that enables myocardial velocities to be detected and makes the quantitative assessment of the systolic and diastolic movements of myocardial walls possible.
This study was designed to test the usefulness both of the right ventricular peak myocardial systolic velocity (Sm) and of the Myocardial performance index (MPI) obtained by pulsed-wave TDI in the diagnosis of RVMI and in determining the infarct-related artery (IRA) in patients with acute inferior wall myocardial infarctions.

Right ventricular infarction:

Frequency:

Right ventricular infarction usually is noted in association with inferior wall myocardial infarction. The incidence of right ventricular infarction in such cases ranges from 10-50%, depending on the series (Andersen, Nielsen, Falk et al, 1989). Isolated infarction of the right ventricle is extremely rare.

Although right ventricular infarction is clinically evident in a sizable number of cases, the incidence is considerably less than that found at autopsy (Andersen, 1987; Andersen, Nielsen, Lund, 1989; Bates, 1997; Birnbaum et al, 1999). A major reason for the discrepancy is the difficulty in establishing the presence of right ventricular infarction in living subjects. Additionally, right ventricular dysfunction and stunning frequently is of a transient nature, such that estimation of its true incidence is even more difficult. Criteria have been set forth to diagnose right ventricular infarction; even when strictly employed, however, the criteria lead to underestimation of the true incidence of right ventricular infarction (Braat et al, 1984; Braat et al, 1983; Elkayam et al, 1979) [3,4]

Importance of identifying RVMI:

Despite the initial observation of serious hemodynamic consequences of right ventricular infarction nearly two decades ago, this condition has received little clinical attention until recent years. Right ventricular infarction contributes markedly to hemodynamic instability, atrioventricular conduction block, and in-hospital mortality in patients with inferior myocardial infarctions.

As compared with all clinical variables available at the time of admission,right ventricular infarction was associated with a relative risk of in-hospitalmortality of 7.7 (95 percent confidence interval, 2.6 to 23) and a risk of major in-hospital complications of 4.7 (95 percent confidence interval, 2.4 to 9). Ultimately, 95 percent of patients without evidence of right ventricular infarction at the time of admission were discharged from the hospital, as compared with only 69 percent of those in whom right ventricular infarction complicated the acute inferior myocardial infarction[5]

Interest in recognizing right ventricular infarction noninvasively has grown because of the therapeutic implications of distinguishing patients with right ventricular dysfunction from those without right ventricular dysfunction .

The potential hemodynamic derangements associated with right ventricular infarction render the afflicted patient unusually sensitive to diminished preload (ie, volume) and loss of atrioventricular synchrony. These two circumstances can result in a severe decrease in right and, secondarily, left ventricular output (Hirsowitz et al, 1984; Hurst, 1998; Iqbal and Liebson,1981)[6].

Infarct Related artery:

The posterior descending branch of the right coronary artery usually supplies the inferior and posterior walls of the right ventricle. The marginal branches of the right coronary artery supply the lateral wall of the right ventricle. The anterior wall of the right ventricle has a dual blood supply: the conus branch of the right coronary artery and the moderator branch artery, which courses from the left anterior descending artery (Forman et al, 1984).

A direct correlation exists between the anatomic site of right coronary artery occlusion and the extent of right ventricular infarction. Studies have demonstrated that more proximal right coronary artery occlusions result in larger right ventricular infarctions (Garty et al, 1984). If occlusion occurs before the right ventricular marginal branches, and collateral blood flow from the left anterior descending coronary artery is absent, then the size of infarction generally is greater. Extent of infarction depends somewhat on flow through the thebesian veins (Kinn et al,1995). In general, any major reduction in blood supply to the right ventricular free wall portends an adverse prognosis in association with this disorder[7.]

Clinical features

- A right ventricular infarct should be considered in all patients who present with an acute inferior wall myocardial infarction, especially in the setting of a low cardiac output.
- Patients may describe symptoms consistent with hypotension.
- A subtle clue to the presence of hemodynamically significant right ventricular infarction is a marked sensitivity to preload-reducing agents such as nitrates, morphine, or diuretics (Mittal, 1994)[8.]
- Other presentations include high-grade atrioventricular block, tricuspid regurgitation, cardiogenic shock, right ventricular free wall rupture, and cardiac tamponade.

Physical signs

- The classic clinical triad of right ventricular infarction includes distended neck veins, clear lung fields, and hypotension (Mavric et al, 1990)[9.]
- Infrequent clinical manifestations include right ventricular third and fourth heart sounds, which are typically audible at the left lower sternal border and increase with inspiration.
- On hemodynamic monitoring, disproportionate elevation of right-sided filling pressures compared with left-sided hemodynamics represents the hallmark of right ventricular infarction.

Diagnosis

Electrocardiography

- All patients with inferior wall myocardial infarction should have a right- sided ECG. ST-segment elevation in lead V4R predicts right ventricular involvement, identifying a high-risk subset of patients in the setting of inferior wall myocardial infarction (Robalino et al, 1990)[10]. ST-segment elevation in lead V_{4R} had an overall sensitivity of 76 percent, a specificity of 78 percent, and a diagnostic accuracy of 72 percent for the diagnosis .

Limitations of the Electrocardiogram in the Diagnosis of Right Ventricular Infarction

The use of ST-segment elevation in lead V_{4R} for the diagnosis of right ventricular infarction has it's own limitations. The ST-segment elevation is transient, disappearing in less than 10 hours following its onset in half of patients. The use of ST-segment elevation in lead V_{4R} for the diagnosis of right ventricular infarction is known to lose specificity in the presence of any heart disease that may induce ST-segment elevation in lead V_1, such as pericardial disease, acute pulmonary embolism, left anterior fascicular block, and acute anterior myocardial infarction (present in 10 percent of patients with right ventricular involvement).[11,12]

Imaging Studies

- In the appropriate clinical setting, a diagnosis of right ventricular infarction can be made using noninvasive techniques, or the patient may require right ventricular catheterization and hemodynamic monitoring.

Echocardiography

- Right ventricular dilatation, abnormal right ventricular wall motion, paradoxical motion of the interventricular septum, and tricuspid regurgitation are echocardiographic features of right ventricular infarction.
- It is difficult to assess both right ventricular anatomy and function with reliable conventional echocardiographic examination because of its complex structure. In most cases, the visual assessment of the right ventricular free wall by echocardiography leads to an underestimation of hypokinesia, due to an asymmetric contraction of the right ventricular walls toward its center.
- In the vast majority of patients with right ventricular infarction, the wall motion abnormalities initially manifest on echocardiography reverse within 3 months (Strauss et al, 1980)[13]
- Echocardiography is useful as a modality to rule out pericardial disease and tamponade, which are the major differential diagnoses in the setting of a right ventricular infarction.
- Echocardiogram has an 82% sensitivity and 93% specificity in detecting right ventricular infarction when right ventricular scintigraphy is used as the comparative standard (Singhal et al, 1984)[14]
- Gated equilibrium radionuclide angiography and technetium 99m pyrophosphate scintigraphy are useful in diagnosing right ventricular infarction noninvasively (Sugimoto et al, 1996)[15] In the case of radionuclide angiography, the right ventricle is demonstrated to be enlarged and poorly contractile, with a reduced ejection fraction. When technetium 99m pyrophosphate is employed, the right ventricular free wall is "hot," indicating significant infarction.

HEMODYNAMIC MONITORING

Disproportionate elevation of right-sided filling pressures when compared with left-sided hemodynamics represents the hallmark of right ventricular infarction.
Accepted hemodynamic criteria for right ventricular infarction include right atrial pressure greater than 10 mm Hg, right atrial–to–pulmonary capillary wedge pressure ratio greater than 0.8 .These values may manifest only after volume loading (Sugiura et al, 1994)[16] Other interesting hemodynamic features of right ventricular infarction include the following:

- Prominent "y" descent of the right atrial pressure

- Increase in venous or right atrial pressure with inspiration (ie, Kussmaul sign)

TISSUE DOPPLER ECHOCARDIOGRAPHY

Tissue Doppler (TD) imaging is a novel echocardiographic technique that measures myocardial velocities. However, there are sparse data on TD imaging of the right ventricular (RV) free wall in the diagnosis and prognosis of RV yocardial infarction (MI) in inferior wall left ventricular MI.. As determined from the position of the right ventricle tricuspid annulus by TDI, myocardial velocities and the myocardial performance index (MPI) can give information about right ventricular function. The evaluation of velocities using DTI provides a noninvasive and rapid method for assessing right ventricular function in patients with RVMI

Tissue Doppler imaging (TDI)

The pulsed and color Doppler echocardiography can detect motion and velocity of both moving blood and myocardial tissue. We have traditionally processed blood flow signals in the conventional Doppler flow imaging, so that the high velocity and low amplitude Doppler signals reflected by the moving blood are measured whereas the myocardial Doppler signals with high amplitude but low velocity are suppressed.

TDI is a new ultrasound technique that is based on color Doppler imaging principles and allows quantification of intramural myocardial velocities by detection of consecutive phase shifts of the ultrasound signal reflected from the contracting myocardium. To display regional myocardial velocities, thresholding and filtering algorithms are changed to reject the low-amplitude echoes from the blood pool. These improve the ability to measure low velocity myocardial signals that are typically in the range of 0.6 – 24 cm/s.

PRINCIPLES OF TISSUE DOPPLER IMAGING

Unlike conventional Doppler signals that are typified by high velocity and low amplitude, myocardial motion is characterized by relatively low velocity and high amplitude signals. Tissue motion creates Doppler shifts that are approximately 40 dB higher than Doppler signals from blood flow whereas velocities rarely exceed 20 cm/s. To record low wall motion velocity, gain amplification is reduced and high pass filters are bypassed with the tissue signal directly entered into the autocorrelator. During image acquisition, it is important to optimise the frame rate using an image sector as narrow as possible and to select the appropriate velocity scale. These parameters should be optimised at the time of imaging, as it is not possible to modify the frame rate and the velocity scale during post processing image analysis.

MODALITIES OF TISSUE DOPPLER ECHOCARDIOGRAPHY

TDE has three modalities: spectral pulsed wave Doppler, two dimensional, and M mode colour Doppler.

Spectral Pulsed Doppler

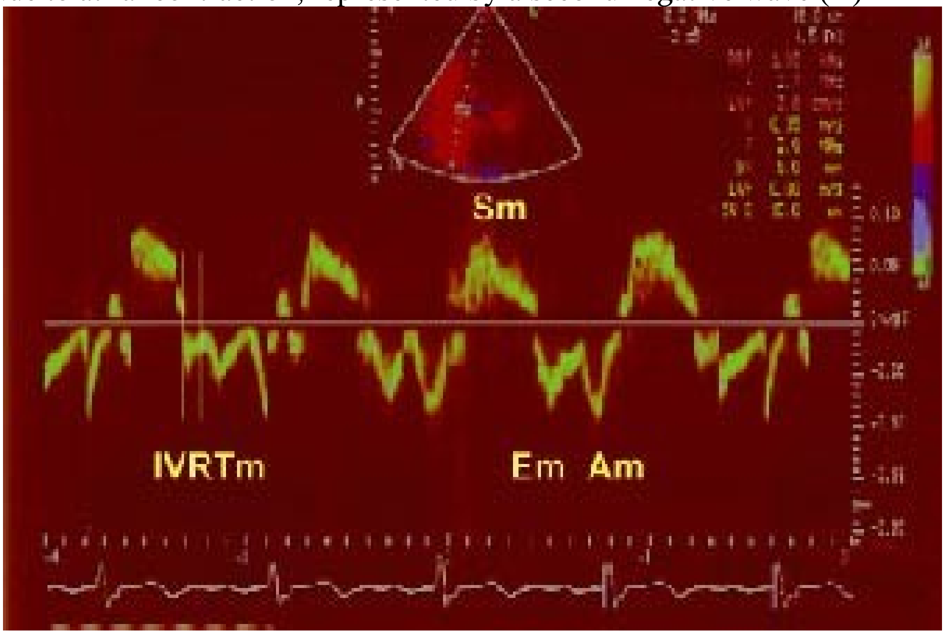
Spectral pulsed TDI has the advantage of online measurements of velocities and time intervals and an excellent temporal resolution (8 ms). According to the Doppler principle, tissue velocities moving toward the transducer are positive, whereas velocities moving away from the transducer are negative. The spectral PW-TDI method provides higher temporal resolution and resolves all peak velocities. With this modality a sample volume is placed within the myocardium (either in the endocardium or the epicardium) and the low doppler shift of frequencies recorded from the heart wall moving through the sample volume during the cardiac cycle is recorded.

The pattern can be divided into two parts systolic and diastolic, from which several measurements can be obtained: 1. The systolic phase is characterized by a positive wave (S) preceded by the time taken for regional isovolumic contraction (RIVCT); 2. The diastolic phase, which is complex, is composed of 4 periods: a) regional isovolumic relaxation (RIVRT);

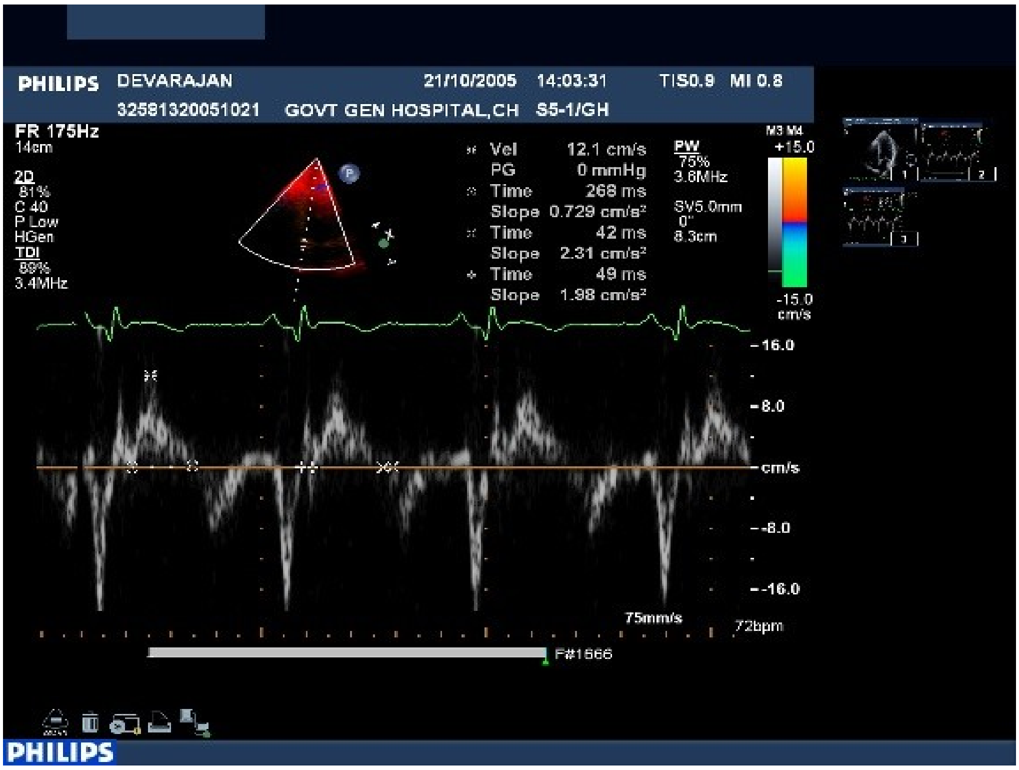
b) the rapid filling period characterized by a negative wave (E);

c) diastasis, and

d) filling due to atrial contraction, represented by a second negative wave (A)



Real-time pulse-wave tissue Doppler at the inferior aspect of the mitral annulus Sm= Systolic mitral annular velocity; Em= Early diastolic mitral annular velocity; Am= Late diastolic mitral annular velocity; IVRTm= isovolumic relaxation velocity; IVCTm= isovolumic contraction velocity



Pulse-wave tissue Doppler at the inferior aspect of the tricuspid annulus for obtaining systolic (Sm) and diastolic (Em and Am) myocardial velocities from right ventricular lateral wall.

Colour Doppler

In colour TDI, red encodes wall motion towards the transducer (positive velocities), whereas blue encodes wall motion away from the transducer (negative velocities). On each side of the scale, the brightest shades correspond to the highest velocities. Colour images require digital acquisition and storage for off-line post-processing analysis. In contrast to spectral Doppler, endocardial and epicardial layers can be separately analysed. Peak and mean velocities, time velocity integral, and regional time intervals can be measured in each myocardial segment, in each myocardial layer, and in each phase of the cardiac cycle. M mode colour encoded TDI has a high temporal resolution (5–10 ms). Colour two dimensional imaging has been limited by a slow frame rate, but parallel processing and advances in beam formation technology have increased the frame rate to a level adequate for analysis of most cardiac events (temporal resolution 10–100 ms)

Potential Clinical Implications of Pulsed TDI

Global assessment of LV function

The global LV systolic function can be assessed by peak mitral annular (MA) velocity in apical views. Although myocardial synchronous contraction and relaxation depends critically on coordination of circumferential and longitudinal fibers, the longitudinal fibers are particularly vulnerable to myocardial ischemia and activation disturbance likely related to their subendocardial position . Because the epicardial apex is relatively fixed, the longitudinal fiber shortening draws the atrioventricular ring towards the apex of the ventricle. Not only does this contribute to the fall in the left ventricular cavity volume with ejection, but at the same time increases the volume of the left atrium[17,18]

Similarly, during diastole, the backward movement of the atrioventricular ring aids the LV filling. Dumesnil et al. showed that with a 40% decrease of LVEF (M-mode) in disease, there might be only 15-20% corresponding decrease in the circumferential fiber (short-axis) shortening, highlighting the significant contribution of longitudinal fibers in overall LV function. Since the introduction of the concept of mitral annular descent by echocardiography in 1967, it has been shown that the peak systolic mitral annular amplitude and total excursion correlate well with LV stroke volume.

Its amplitude and velocity have been used as an index of ejection fraction (EF) and been shown to correlate with the LVEF obtained by radionuclide ventriculography in humans. Tissue Doppler not only defines and measures the mitral annular movement, but also gives high temporal relationship. Decrease in peak systolic descent velocity at a mitral annular site with corresponding longer time to peak correlates with LV asynergy and infarct regions in patients with previous myocardial infarction[19,20,21,22]

The mitral annular velocity has also been shown to be a sensitive marker of alteration of LV contractility induced by inotropic stimulation. In studying 12 normal volunteers, Gorcsan et al. showed that peak mitral annular velocity increased significantly with corresponding decrease in time to peak velocity at very low dose (1mcg/kg/min) dobutamine.

A further linear dose- dependent incremental increase of the velocity was observed up to the target infusion of 5mcg/kg/min. In contrast, regional peak velocities did not change until the 2mcg/kg/min dose and no change of myocardial wall thickening and ejection fraction was observed until 3mcg/kg/min. These data support the mitral annular velocity as a sensitive marker of global systolic function, even when the endocardial definition is suboptimal for estimation of LV volumes and ejection fractions. The MA velocity provides important insight in terms of amplitude, velocity and timing in relation to the cardiac cycle[23,24]

Diastolic Function

Analysis of the motion of the myocardium during diastole with TDI has been performed in healthy normal subjects. The PW-TDI provides a mirror image of the initial inflow patterns, with a decrease in the E/A velocity ratio with age. Myocardial diastolic velocities have been reported in various diseases, allowing a differentiation between constrictive pericarditis and restrictive cardiomyopathy, as well as among the different patterns of myocardial hypertrophy.

Mitral annular E velocities have been proposed to be preload-independent variables of diastolic function. However, subsequent work by other investigators have debated the load independence of Ea. In day-to-day practice it is often necessary to obtain a noninvasive judgment regarding the left ventricular filling pressures for guiding the management of patients with cardiac diseases. Nagueh et al. proposed a ratio of E/Ea as an important tool for noninvasive assessment of the left ventricular filling pressure.

They studied 125 patients and divided them into three groups: asymptomatic persons with left ventricular E/A >1 (normal), E/A <1 (impaired relaxation) and E/A>1 but with symptoms of heart failure (pseudonormal). Ea was reduced in patients with impaired relaxation and pseudonormal pattern. The best correlation for pulmonary artery wedge pressure was with E/Ea ratio (r=0.87).

Nagueh et al. in their second study showed that the ratio of E/Ea could be used to estimate pulmonary artery wedge pressure accurately even in the presence of sinus tachycardia. They studied 100 cases, which included 35 patients with completely merging E and A mitral inflow velocity waves, and found strongest correlation of pulmonary capillary wedge pressures [PCWP] with E/Ea ratio (r=0.86, PCWP=1.55+1.47 E/Ea). The best cut-off was a value of E/Ea >10 that predicted a PCWP of >15 with a 92% sensitivity and 80% specificity. Dagdelen et al. evaluated the utility of deceleration time of mitral annular Ea, Aa time and Ea/Aa ratio in estimating left ventricular end-diastolic pressure in 70 hypertensive patients with no significant coronary artery disease and normal left ventricular systolic function but with varying left ventricular end-diastolic pressures. The best sensitivity and specificity values for predicting left ventricular end-diastolic pressure of >15 mmHg were Ea DT >120 ms (88% and 81%), Aa time >110 ms (71% and 80%) and Ea/Aa <0.5 (86% and 72%), respectively[25,26,27,28,29.]

Tissue Doppler Imaging in Coronary Artery Disease

Myocardial ischemia alters regional contraction and relaxation. An acutely ischemic myocardium suffers not only from the loss of contractility but also tensile strength and stiffness. These alterations can be quantified by tissue velocity imaging.

Derumeaux et al. studied the patterns of tissue velocity profile during graded ischemia in an animal model and observed that ischemia resulted in rapid reduction of systolic velocities and early diastolic velocities. Within 5 s of occlusion of the left anterior descending (LAD) artery, a 46% reduction in systolic velocities was seen.

Systolic waves became negative at around 30 s and peaked at 1 min. This corresponded to paradoxical expansion of the same segment. Diastolic abnormalities also occurred simultaneously and were characterized by a decrease in Em wave and increase in Am wave. The velocity of isometric relaxation and contraction increased and peaked at 1 min. There was a good correlation between decrease of systolic velocity and regional myocardial flow.

In another animal model, Pislaru et al. measured the transmural extent of necrosis in the myocardium after occlusion of the LAD artery for one to two hours and its effect on myocardial contraction and relaxation velocities. The isovolumic contraction wave was found to be absent in the presence of >20% necrosis of the myocardial thickness and preserved in animals with less than 20% necrosis of thickness of the myocardium. Wall thickening did not improve with reperfusion. However, positive isovolumic contraction velocities were able to distinguish segments with different degrees of necrosis.

Preserved isovolumic contraction waves in hypokinetic or akinetic segments were associated with smaller infarcts. However, it needs to be pointed out that ischemia and perfusion-induced contractile dysfunction resemble each other and therefore cannot be differentiated. Estimation of myocardial perfusion through myocardial velocities, therefore, is only valid in the situation of ongoing ischemia and not following reperfusion.

In patients with chronic stable angina and normal ejection fraction, minor abnormalities of LV isovolumic relaxation and contraction and longitudinal shortening can be detected on tissue Doppler imaging (TDI). TDI has also been used during stress echocardiography for quantifying regional wall motion abnormalities. Katz et al. evaluated the utility of TDI in 60 patients for detecting wall motion abnormalities. Excluding the apical segments, a peak velocity of less than 5.5 cm/s with peak stress had an average sensitivity, specificity and accuracy of 96%, 81% and 86%, respectively, for identifying abnormal segments at peak stress.

Dobutamine stress echocardiography using TDI is also an accurate tool for assessing myocardial viability. Larrazet et al. evaluated the concordance between dobutamine stress echocardiography using TDI, dobutamine stress using standard echocardiography and thallium-201 SPECT for viability assessment in 23 patients with coronary artery disease (CAD) and resting LV dysfunction. Compared to dobutamine stress using standard echocardiographic evaluation of regional wall motion abnormalities, dobutamine TDI had a higher sensitivity (60% *v.* 82%), equal specificity (100% each) and higher accuracy (74% *v.* 94%) for detecting viable myocardium using thallium-201 as the gold standard. Nishino et. al. evaluated conventional dobutamine stress echocardiography (DSE) and color TDI (M-mode) for predicting viable myocardium in 56 patients undergoing corornary angioplasty.

Dobutamine TDI, either used alone or in combination with conventional stress echocardiography, had a higher sensitivity and equivalent specificity for the prediction of recovery of dysfunctional segments. Tissue Doppler imaging is thus a useful technique during stress echocardiography for counterbalancing the poor agreement of standard echocardiography for evaluating wall motion. It has been shown to significantly improve the accuracy of dobutamine stress echocardiography interpretation by novices as well as experienced echocardiographers not formally trained in stress echocardiography. The tissue velocity profile is particularly important in interpreting regional wall motion in the basal segments. In a study of 77 patients who underwent dobutamine stress echocardiography and coronary angiography, TDI improved the baseline accuracy for novice readers from 68% to 76% (p=0.001) for basal segments, which were otherwise scored as normal.

Tissue Doppler Imaging in Right ventricular myocardial infarction

Right ventricular myocardial infarction impairs right ventricular function. However, it is difficult to assess both right ventricular anatomy and function with reliable conventional echocardiographic examination because of its complex structure. In most cases, the visual assessment of the right ventricular free wall by echocardiography leads to an underestimation of hypokinesia, due to an asymmetric contraction of the right ventricular walls toward its center. It has been suggested that color or pulsed-wave TDI, which is frequently used in assessing left ventricular function, also can be used to assess right ventricular function. The myocardial velocities obtained by pulsed-wave TDI from the right ventricular free wall at the level of the tricuspid annulus in the apical four-chamber view show the longitudinal dynamics of the right ventricle, which is not seen with visual scoring.

In studies assessing right ventricular function by using techniques other than TDI, the movement of the tricuspid annulus has been shown to represent the global right ventricular function. It has been documented that significant right coronary artery disease can be identified with the assessment of systolic velocity obtained by pulsed-wave TDI from the right ventricular free wall close to the tricuspid lateral annulus in the apical four-chamber view during dobutamine stress echocardiography [30,31,32,33,34] Finally, it has been shown that tricuspid annulus systolic velocity decreases in patients with inferior MIs compared to those with anterior MIs, and in those with RVMIs compared to those without RVMIs.

REVIEW OF LITERATURES

In approximately half of patients with inferior wall myocardial infarction, right ventricular myocardial infarction (RVMI) develops[1,2] In patients with RVMI, the risk of death in the hospital is high and major complications are greater. Despite the initial observation of serious hemodynamic consequences of right ventricular infarction nearly two decades ago, this condition has received little clinical attention until recent years.

Right ventricular infarction contributes markedly to hemodynamic instability, atrioventricular conduction block, and in-hospital mortality in patients with inferior myocardial infarctions. The following studies were conducted to evaluate RVMI and it`s complications.

1. The diagnosis and early complications of right ventricular infarction.

Garty.I, Barzilay.J, Bloch.L, Antonelli.D, Koltun.B

Eur. J Nucl Med. 1984: 9(10):453-60

Sixty patients with AMI were prospectively studied: 40 patients with inferior AMI and 20 patients with anterior AMI. . Of the 40 patients diagnosed as having inferior AMI, 20 cases (50%) were found to be associated with RVAMI. 17 (85%) also demonstrated a ST segment elevation of 0.1 mV, and pathological Q waves in the V4R lead. The ejection fraction (EF) of RV was found to be significantly decreased in patients with RVAMI compared with the other group (mean, 27% versus 57%). Among the 20 patients with RVAMI, 16 (80%) showed various complications during the hospitalization period, versus 9 patients (45%) from the group with inferior AMI. The most common complication in RVAMI patients was conduction disturbances (7 of 20 versus 2 of 20 patients). The clinical and prognostic importance of the early diagnosis of RVAMI is stressed.

2. ***Diagnosis and prognosis of right ventricular infarction.***

Rodrigues E.A, Dewhurst N.G, Smart L.M, Hannan W.J, Muir A.L.

Br Heart J. 1986 Jul;56(1):19-26.

The values of several non-invasive methods for the diagnosis of right ventricular necrosis in inferior myocardial infarction were compared in 51 consecutive patients who underwent serial ECG, radionuclide ventriculography, pyrophosphate scintigraphy, and cross sectional echocardiography. Functionally important right ventricular infarction was best detected and followed serially by radionuclide ventriculography. Echocardiographic methods for evaluating right ventricular ejection fraction correlated poorly with radionuclide methods.

Increased uptake of radioactivity by the right ventricle on pyrophosphate scintigraphy usually indicated poor right ventricular function, but a scan that was negative in the right ventricular territory did not exclude dysfunction. ST segment elevation in V4R was not specific for right ventricular infarction and its routine use may lead to overdiagnosis of this condition. Serial measurements suggest that profound right ventricular dysfunction persists after acute inferior infarction and is associated with considerable morbidity and mortality.

Electrocardiography

All patients with inferior wall myocardial infarction should have a right- sided ECG. ST-segment elevation in lead V4R predicts right ventricular involvement, identifying a high-risk subset of patients in the setting of inferior wall myocardial infarction (Robalino et al, 1990)[10] The use of ST-segment elevation in lead V_{4R} for the diagnosis of right ventricular infarction has it's own limitations. The ST-segment elevation is transient, disappearing in less than 10 hours following its onset in half of patients.The following study was conducted regarding the use of ECG in RVMI.

The diagnostic value of 12-lead electrocardiogram in predicting infarct related artery and right ventricular involvement in acute inferior myocardial infarction. Kabakci.G, Yildirir.A, Yildiran.L, Batur .M.K, Cagrikul .R, Onalan. O, TokgozogluL, Oto. A, Ozmen. F, Kes. S. Hacettepe University Department of Cardiology, Ankara, Turkey

Ann Non invasive Electrocardiol 2001 July; 6 (3) : 229-35

This study investigated the predictive value of presentation and 24-hour electrocardiograms in defining the infarct-related artery (IRA), its lesion segment, and the right ventricular involvement in acute inferior myocardial infarction (MI). One hundred forty-nine patients with acute inferior MI were included. Infarct-related artery, its lesion segment, and the validity of new ECG criteria for the diagnosis of right ventricular MI (RVMI) were investigated. The width of Q wave in lead III > lead II criterion supported the RCA to be IRA with a sensitivity of 60% and a specificity of 61%. The finding of ST elevation in V(1) but no ST elevation in V2) on admission ECG had a sensitivity of 63% and a specificity of 99% in the diagnosis of RVMI. This study concluded that , despite high specificity, due to moderate degree sensitivity, 12-lead ECG for the diagnosis of RVMI is questionable.

Tissue Doppler Imaging in Right ventricular myocardial infarction

It has been suggested that color or pulsed-wave TDI, which is frequently used in assessing left ventricular function, also can be used to assess right ventricular function. The myocardial velocities obtained by pulsed-wave TDI from the right ventricular free wall at the level of the tricuspid annulus in the apical four-chamber view show the longitudinal dynamics of the right ventricle, which is not seen with visual scoring.

In studies assessing right ventricular function by using techniques other than TDI, the movement of the tricuspid annulus has been shown to represent the global right ventricular function. It has been documented that significant right coronary artery disease can be identified with the assessment of systolic velocity obtained by pulsed-wave TDI from the right ventricular free wall close to the tricuspid lateral annulus in the apical four-chamber view during dobutamine stress echocardiography. [30,31,32,33,34] The following studies were conducted to assess the use of Tissue Doppler imaging in inferior/ right ventricular infarction

Assessment of Right Ventricular Function by Tissue Doppler Imaging in Patients with Acute Myocardial Infarction Pramod Jaiswal, Jai Shankar K, Meena Rani, KM Cherian International Centre for Cardiothoracic and Vascular Diseases, Chennai

Right ventricular (RV) function has not been studied widely after a myocardial infarction (MI). The current study was designed to determine the RV function by tricuspid annular motion and tricuspid annular velocity after MI. Ten patients with a first episode of acute MI (inferior MI: 6, anterior MI: 4) and 4 healthy controls were included in the study.

The tricuspid annular motion was reduced in inferior MI compared to controls (19.2 and 24 mm). The peak systolic velocity of tricuspid annulus was reduced in inferior MI compared to controls (12 *v.* 14.2 cm/s), also the tricuspid annular motion was significantly lower in patients with RV infarction than in those without RV infarction (16.8 and 21.6 mm, $p < 0.01$). Patients with RV infarction also had significantly decreased peak tricuspid annular systolic and early diastolic velocities. Thus, tricuspid annular motion and velocity can be used to assess RV function in association with inferior wall myocardial infarction.

Usefulness of tissue Doppler imaging in the diagnosis and prognosis of acute right ventricular infarction with inferior wall acute left ventricular infarction.

Dokainish.H, Abbey.H, Gin.K, Ramanathan.K, Lee.P.K, Jue.J. Department of Medicine, Division of Cardiology, University of British Columbia, Vancouver, Canada Am J cardiol 2005 May 1:95 (9) : 1039-42.

Fifty patients who had left ventricular MI underwent TD echocardiography and angiography within 48 hours of MI. For diagnosis, the ability of RV TD imaging to detect RV MI was assessed using coronary angiography as the reference standard. For prognosis, the ability of TD detection of RV dysfunction to predict cardiac death or rehospitalization at 1 year was determined. On multivariate analysis, systolic annular velocity and RV dimension predicted RV MI. Decreased RV systolic annular velocity on TD images detects RV MI in first left ventricular acute inferior MI and predicted cardiac death or rehospitalization at 1 year.

Evaluation of right ventricular function by tissue Doppler echocardiography and Tei index in right ventricular myocardial infarction Fan.Y, Shen.J.X, Yang.S.S, Xiu.C.H, Wang.L.F, Xue.F.H, Huang.Y.L. Department of Cardiac Medicine, the First Hospital, Harbin Medical University, Harbin 150001, China Zhunghua Neike Zazhi 2005 March; 44 (3)180-3.

With tissue Doppler imaging and right ventricular Tei index, right ventricular function in patients with right ventricular myocardial infarction (RVMI) was assessed. 51 patients admitted to coronary care units and diagnosed as acute inferior myocardial infarction were studied . 23 patients were diagnosed to have RVMI and 28 patients not. 20 healthy subjects served as controls. Sm and Em at the lateral side of tricuspid annulus and the RV free mid-wall reduced significantly in patients with RVMI as compared with those without RVMI and healthy individual s (Sm at the lateral (7.0 +/- 2.0) cm/s vs (8.7 +/- 1.9) cm/s and (10.6 +/- 2.1) cm/s, $P < 0.01$; Em at the lateral (6.3 +/- 1.9) cm/s vs (7.9 +/- 1.8) cm/s and (9.6 +/- 1.9) cm/s, $P < 0.01$; Sm at the RV free mid-wall (6.4 +/- 1.9) cm/s vs (8.0 +/- 1.9) cm/s and (9.4 +/- 2.0) cm/s, $P < 0.05$; Em at the RV free mid-wall (6.1 +/- 2.0) cm/s vs (7.6 +/- 2.0) cm/s and (9.2 +/- 2.3) cm/s, $P < 0.05$). RV Tei index in patients with RVMI also increased as compared with that in the other two groups (0.65 +/- 0.19 vs 0.40 +/- 0.15 and 0.26 +/- 0.10; $P < 0.01$: The evaluation of velocities at the lateral side of tricuspid annulus and the RV free mid-wall using DTI and RV Tei index provides a noninvasive and rapid method for assessing right ventricular function in patients with RVMI.

Colour tissue Doppler echocardiographic evaluation of right ventricular function in patients with right ventricular infarction. Oguzhan.A, Abaci.A, Eryol.N.K, Topsakal.R,Seyfeli.E. Department of Cardiology, Erciyes University School of Medicine, Kayseri, Turkey Cardiology 2003; 100(1) 41-6.

This study was undertaken to determine right ventricular (RV) function as assessed by colour Doppler tissue imaging (DTI) in patients with RV infarction. 35 patients were evaluated: 14 patients had an inferior myocardial infarction (MI) with RV infarction and 21 patients had an inferior MI without RV involvement. Twenty age-matched healthy subjects served as control.: Systolic and early diastolic velocities at the lateral tricuspid annulus were significantly reduced in patients with inferior MI with RV infarction compared with those in healthy individuals (7.8 +/- 1 vs. 11 +/- 2 cm/s, $p < 0.002$) and patients with inferior MI without RV infarction (7.8 +/- 1 vs. 10 +/- 1 cm/s, $p < 0.002$). The late diastolic lateral annular velocity did not differ between the groups. Systolic and early diastolic RV free wall velocities were also significantly decreased in patients with RV infarction compared with those in healthy individuals (7 +/- 1 vs. 8.7 +/- 1 cm/s, $p < 0.01$; 6.3 +/- 2 vs. 8.7 +/- 2 cm/s, $p < 0.05$, respectively) and patients with inferior MI without RV infarction (7 +/- 1 vs. 9 +/- 2 cm/s, $p < 0.01$; 6.3 +/- 2 vs. 8.3 +/- 2 cm/s, $p < 0.05$, respectively). The evaluation of tricuspid annular and RV free wall velocities using colour DTI provides a rapid and noninvasive tool for assessing RV function in patients with RV infarction.

Tissue doppler echocardiography of the tricuspid annulus in the detection of right ventricular infarction in acute inferior wall myocardial infarction. H.Dokainish, K. Gin, K. Ramanathan, P.Lee, J. Jue Vancouver, British Columbia Canadia CV Congress 2003

This study assessed echocardiographic variables including TDI of the tricuspid valve annulus to detect RVI in the setting of acute inferior wall myocardial infarction (IWMI).
50 patients were included in the study. 22 patients (44%) had the ICL proximal to the first RV branch of the RCA (Group 1, RVI), while 28 patients had the ICL distal to the first RV branch of the RCA or in an artery other than the RCA (Group 2, No RVI). The univariate predictors of RVMI were: elevation of the jugular venous pressure > 4 cm, ST elevation in lead V4R, abnormal echo RV function by visual inspection, right ventricular dimension (RVD), and tricuspid annular systolic velocity (TAV) (Table). On logistic regression analysis including all significant univariate variables, only TAV (odds ratio 0.62, p=0.03) and RVD (odds ratio 1.28, p=0.013) predicted RVI.
Of various clinical and echocardiographic variables, reduced systolic velocity of the tricuspid annulus by TDI and increased right ventricular dimension are multivariate predictors of RVI in patients presenting with first ST elevation IWMI.

ABBREVIATIONS

Am = late phase of diastolic myocardial velocity;
E/A = E-wave/A-wave ratio;
Em = early phase of diastolic myocardial velocity;
ET = ejection time;
ICT = isovolumetric contraction time;
IRA = infarct-related artery;
IRT = isovolumetric relaxation time;
MI = myocardial infarction;
MPI = myocardial performance index;
PD = pulmonary peak diastolic velocity;
PS = venous peak systolic velocity;
RVMI = right ventricular myocardial infarction;
Sm = myocardial systolic velocity;
TDI = tissue Doppler imaging

USEFULNESS OF TISSUE DOPPLER IMAGING FOR THE DIAGNOSIS OF RIGHT VENTRICULAR MYOCARDIAL INFARCTION AND DETERMINATION OF INFARCT RELATED ARTERY IN ACUTE INFERIOR WALL MYOCARDIAL INFARCTION

Abstract

Aim:

The aim of the study is to find out the usefulness both of peak myocardial systolic velocity (Sm) and of the myocardial performance index (MPI) of the right ventricle measured by pulsed-wave tissue Doppler imaging (TDI) to diagnose right ventricular myocardial infarction in the presence of acute inferior wall myocardial infarction.

Methods:

Forty patients who experienced a first acute inferior MI (mean [± SD] age, 57 ± 9 years) were prospectively assessed. An ST-segment elevation of 0.1 mV in V4-V6R lead derivations was defined as an RVMI. From the echocardiographic apical four-chamber view, the myocardial systolic velocity Sm, the peak early diastolic velocity Em , peak late diastolic velocity Am, the ejection time, the isovolumetric relaxation time, and the contraction time of the right ventricle were recorded at the level of the tricuspid annulus by using TDI. Then, the MPI was calculated. The patients were classified into the following three groups, according to the localization of the infarct-related (IRA) detected using coronary angiography: group I, proximal right coronary artery; group II, distal right coronary artery; and group III, circumflex coronary artery.

Results:

RVMIs were detected in fifteen patients, and the IRA in 18 patients was the proximal right coronary artery. The right ventricular Sm was observed to be significantly low in patients with RVMIs and those in group I compared to those without RVMIs and those in groups II and III (11.5 ± 2.5 vs 15.1 ± 3 cm/s, respectively; and 14.9 ± 2.6 cm/s, respectively [$p < 0.001$])., The MPI was high in the same patient groups (0.74 ± 0.13 vs 0.56 ± 0.15 in group II and 0.54 ± 0.07 in group III, respectively [$p <0.001$]). In the diagnosis of RVMI , and in the diagnosis of the proximal right coronary artery as the IRA, the sensitivity, specificity, negative predictive value, and positive predictive value of an Sm < 12 cm/s were calculated as 83%, 93%, 90%, and 88%. The sensitivity, specificity, negative predictive value, and positive predictive value of an MPI of > 0.70 were 78%, 91%, 88% and 82%.

Conclusion:

An Sm <12 cm/s and an MPI > 0.70 obtained by TDI may define RVMI concomitant with acute inferior myocardial infarction, and the Infarct related artery.

AIM

To assess the usefullness of Pulsed tissue Doppler and Myocardial performance index in assessing Right ventricular function for the diagnosis of Right ventricular Myocardial infarction in the presence of Inferior wall Myocardial infarction

Methods

Study subjects:

Included in this prospective study were 40 patients (30 men and 10 women; mean [± SD] age, 57 ± 9 years) with inferior MIs who had been admitted to the coronary care unit at the onset of acute chest pain within the previous 24 h. A standard 12-lead ECG and a right chest ECG (V_4 through V_6R leads) were recorded. Chest pain lasting for > 30 min, characteristic ST-segment elevation of ≥0.1 mV in two or more inferior derivations (*ie*, leads II, III, and aVF) on ECGs, and a creatine kinase-MB value more than twice that of the highest reference laboratory value were defined as acute MI criteria. The localization also was confirmed by the detection of hypokinetic and/or akinetic segments by echocardiography. The presence of an RVMI in association with an inferior MI was defined by an ST-segment elevation of > 0.1 mV in V_4 through V_6R lead derivations. Accordingly, RVMI was identified in 15 patients. Twenty eight patients received thrombolytic therapy. Patients who had experienced MIs in the past, or had valvular disease, left and right bundle-branch block, or atrial fibrillation were excluded from the study.

Echocardiography

Two-dimensional, pulsed Doppler and color-flow Doppler echocardiography examinations were performed within two days after the onset of symptoms. A cardiac ultrasonographic unit the Philips IEE 32, Aloka all equipped with a variable-frequency phased-array transducer and TD capabilities was used. All the echocardiographic measurements were performed according to the recommendations of the American Echocardiography Association without any information about the ECG findings.

Doppler Echocardiography

From the apical four-chamber view, Doppler recordings were obtained with the pulsed sample volume placed at the tip of the mitral leaflets. The early peak filling velocity (E wave), the late peak filling velocity (A wave) and the E-wave deceleration time were measured, and the E-wave/A-wave (E/A) ratio was calculated.

The pulmonary venous flow was recorded from the apical four-chamber view by inserting the pulsed-wave Doppler sample volume approximately 1 cm into the right upper pulmonary vein. The venous peak systolic velocity (PS), the pulmonary peak diastolic velocity (PD), the PS/PD ratio, and the atrial reverse-flow velocity were recorded. In the presence of tricuspid regurgitation, the pulmonary artery systolic pressure was calculated from the sum of the estimated mean right atrial pressure, and the maximum pressure difference between the right ventricle and right atrium, as determined by continuous-wave Doppler echocardiography.

Annular Velocities Obtained by TDI

Pulsed-wave TDI images were acquired by activating the TDI function of the cardiac ultrasonographic unit. The best recordings were obtained by optimizing the gains to terminate the signals formed by the transmitral flow and to reduce the noise with the use of low wall filter settings (*ie*, 50 Hz). A 3.5-mm sample volume was used. From the apical four-chamber view, the TDI cursor was placed to the right of the ventricular free wall and the interventricular septum at the level of the tricuspid annulus in such a way that the annulus moved along the sample volume line.

A major positive Sm was recorded with the movement of the annulus toward the cardiac apex during systole. Two major negative velocities were recorded with the movement of the annulus toward the base of the heart during diastole, as follows: one during the early phase of diastolic myocardial velocity (Em) and another during the late phase of diastolic myocardial velocity (Am). In the TDI images, Sm duration was measured as the ejection time (ET), the time between the end of the Sm and the beginning of the Em as isovolumetric relaxation time (IRT), and the time between the end of Am and the beginning of Sm as isovolumetric contraction time (ICT)

The right ventricular MPI was calculated as (IRT + ICT)/ET, by using the values obtained from the right ventricular free wall. In this study, a Doppler velocity range of -20 to 20 cm/s was selected, and the velocities were measured on-line at a sweep of 50 mm/s. A mean of three consecutive cycles was used to calculate all Doppler echocardiographic parameters.

Coronary angiography

Coronary angiography and left ventriculography were performed to detect the IRA within the first month after the MI. Total or subtotal occlusion of the coronary artery supplying the asynergic field was accepted as the defining features for the IRA. The patients were divided into two groups according to the level of the right coronary artery lesion when the IRA was the right coronary artery. The patients with the lesion proximal to the marginal branch of the right coronary artery were defined as group I, whereas those with the lesion distal to the marginal branch of right coronary artery were defined as group II.

The patients in whom the IRA is the circumflex artery were defined as group III. Those patients in whom the IRA could not be identified were excluded from the study. Coronary angiograms using the Judkins technique were performed with a standard cineangiographic system in multiple views. Lumen diameter narrowing was graded as 0, < 25, 25, 50, 75, 90, and 100% . In the present study, the definition of a significant anatomical stenosis implied a >70% localized luminal narrowing .

Statistical analysis:

Variables are presented as mean ± 1 SD. Analysis of variance was performed to estimate intergroup differences. Linear regression analyses and partial correlation testing using Pearson's method were used to assess univariate relations. The prediction of RVMI was made using stepwise, forward, multiple regression analyses that included potential confounding variables not obviously related to each other. The null hypothesis was rejected for $p < 0.05$.

Results

The clinical parameters were comparable in the groups based on the IRA. The number of the patients receiving thrombolytic therapy, and the peak values of creatine kinase and transaminase did not differ between the groups. The percentage of the occlusion of the IRA were comparable. (Table 1) The conventional Doppler parameters obtained from pulmonary venous flow in all three groups were also the same.

Table 1
Comparison of the Baseline Clinical and Angiographic Parameters Among Patient Groups*

Variables	*Group I (n = 18)*	*Group II (n = 12)*	*Group III (n = 10)*
Age, yr	54 ± 10	57 ± 8	59 ± 7
SBP, mm Hg	108 ± 16	104 ± 26	114 ± 13
DBP, mm Hg	71 ± 8	74 ± 10	74 ± 10
Heart rate, beats/min	72 ± 11	70 ± 8	76 ± 9
BMI	26 ± 3	28 ± 4	26 ± 3
Thrombolytic therapy	14	8	6
Creatine kinase MB	115 ± 42	67 ± 18	157 ± 41
SGOT	113 ± 30	77 ± 20	150 ± 35
IRA lesion, %	93 ± 7	87 ± 11	90 ± 9

*Values given as mean ± SD or No. (%). SBP = systolic BP; DBP = diastolic BP; BMI = body mass index; SGOT = serum glutamate oxalate transaminase; IRA = infarct related artery

Annulus Velocities and MPI Obtained by TDI:

In the comparison of patient groups with and without RVMI (based on the IRA), the values for Sm, Em, and Am obtained from the interventricular septum were lower in those with RVMIs than in those without, but the difference was insignificant However, the Sm, Em, and ET values obtained from the right ventricular free wall were significantly lower, and IRT and ICT values were significantly higher in those with RVMIs than in those without (Table–2). The right ventricular MPI was calculated to be higher in those with RVMI than in those without RVMI.

Table 2
Comparison of the Tissue Doppler Parameters Obtained from the RV Free wall in Patients With and Without RVMI

Parameters	RVMI (+) (n = 18)	RVMI (-) (n = 22)	P Value
Sm, cm/s	10.9 ± 1.3	14.3 ± 3.2	< 0.01
Em, cm/s	8.6 ± 1.8	10.1 ± 3.4	< 0.001
Am, cm/s	13.8 ± 3.5	14.8 ± 4.4	NS
Em/Am	0.65 ± 0.16	0.72 ± 0.25	NS
IRT, ms	115 ± 13	89 ± 19	< 0.01
ICT, ms	82 ± 17	71 ± 16	< 0.05
ET, ms	241 ± 16	282 ± 22	< 0.01
MPI	0.83 ± 0.12	0.57 ± 0.11	< 0.05

Table 3
Comparison of the Tissue Doppler Parameters Obtained from the Interventricular Septum in Patients With and Without RVMI

Parameters	RVMI (+) (n = 18)	RVMI (-) (n = 22)
Interventricular septum		
Sm, cm/s	5.9 ± 1.4	6.5 ± 1.6
Em, cm/s	5.4 ± 1.5	5.7 ± 1.7
Am, cm/s	7.7 ± 2.3	8.8 ± 2.3
Em/Am	0.77 ± 0.31	0.69 ± 0.26
IRT, ms	111 ± 13	116 ± 21
ICT, ms	75 ± 12	83 ± 19
ET, ms	259 ± 24	253 ± 22

Values given as mean ± SD. P value – Not significant

Table 4
Comparison of the Right Ventricular Velocities and the MPI by Patient Group

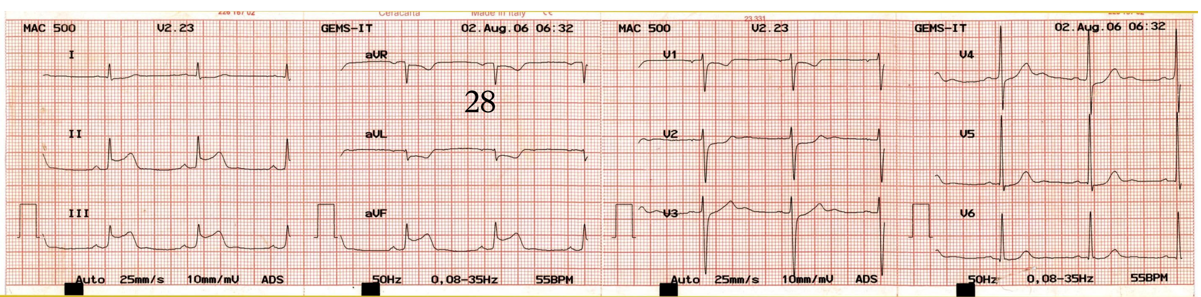
Variables	*Group I (n = 18)*	*Group II (n = 12)*	*Group III (n = 10)*	*P value*
Sm, cm/s	11.5± 2.5	15.1 ± 3	14.9 ± 2.6	p < 0.01(I compared with group II & III).
Em, cm/s	8.7 ± 2.7	9.4 ± 1.9	12.3 ± 4.2	p < 0.01(I compared with group III).
Am, cm/s	13.7 ± 3.8	14.8 ± 4.2	15.9 ± 4.6	NS
Em/Am	0.66 ± 0.18	0.68 ± 0.22	0.81 ± 0.32	NS
IRT, ms	108 ± 19	84 ± 18	89 ± 16.	p < 0.001(I compared with group II).
ICT, ms	78 ± 14	75 ± 19	64 ± 14	p < 0.05(I compared with group III).
ET, ms	253 ± 21	287 ± 27	285 ± 16	p < 0.001(I compared with group II &III).
MPI	0.74 ± 0.13	0.56 ± 0.15	0.54 ± 0.07	p < 0.001(I compared with group II &III).

Values given as mean ± SD. NS= Not significant

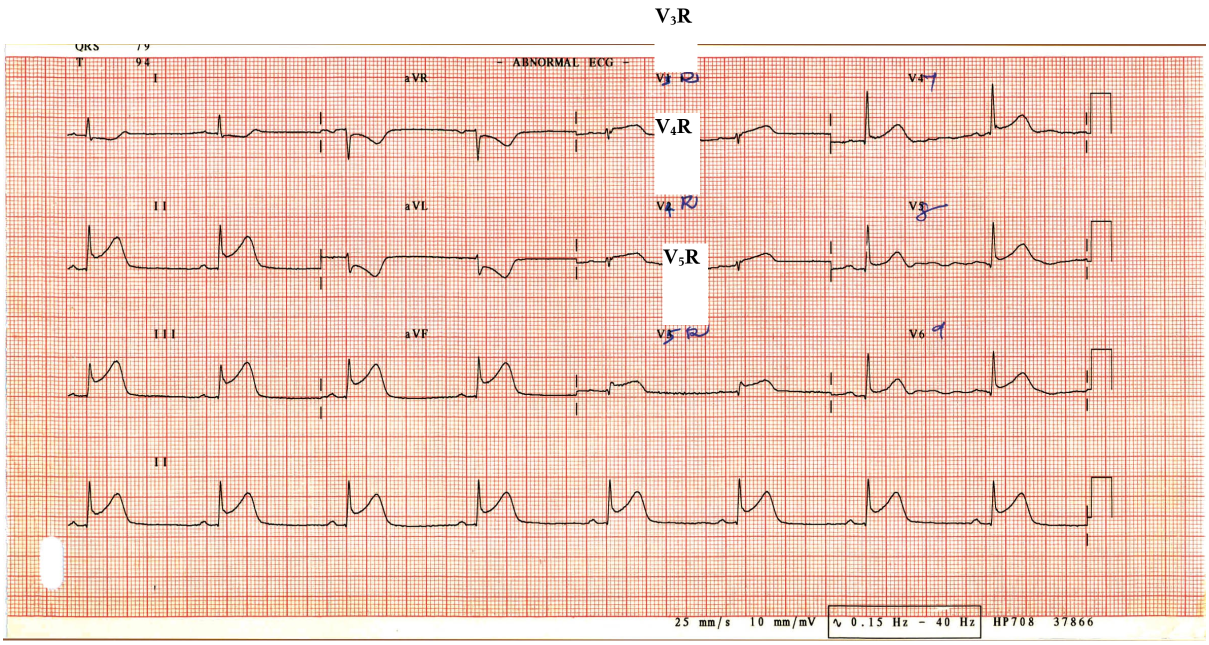
The Role of Right Ventricular Sm and MPI Obtained by TDI in the Identification of RVMI and the Localization of IRA:

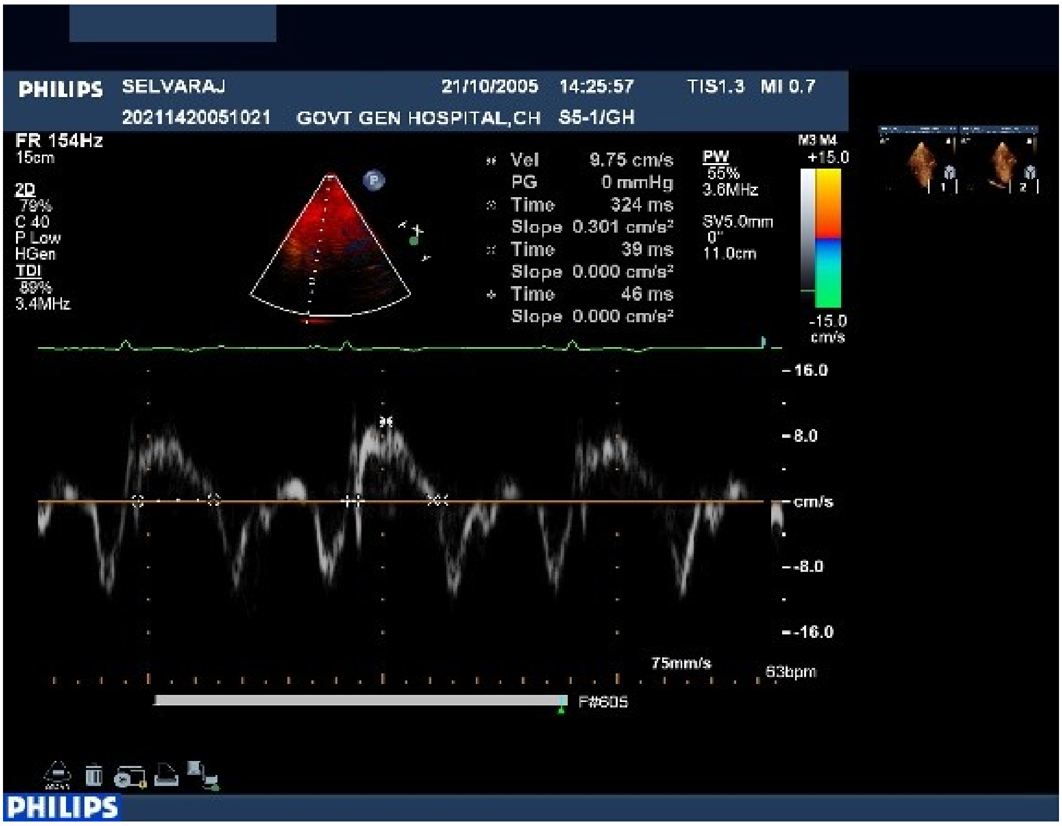
In the patient groups, the right ventricular free wall mean Sm was 11.5 ± 2.5 cm/s in group I and the mean right ventricular MPI was 0.74 ± 0.13. Accordingly, Sm < 12 cm/s identifies RVMI and IRA (the proximal right coronary artery lesion) with the sensitivity (83%), specificity (93%), negative predictive value (90%), and positive predictive value(88%). MPI of >0.70 identifies RVMI and IRA (the proximal right coronary artery lesion) with the sensitivity (78%), specificity (91%), negative predictive value(88%), and positive predictive value(82%).

Electrocardiogram in patient with inferior wall myocardial infarction

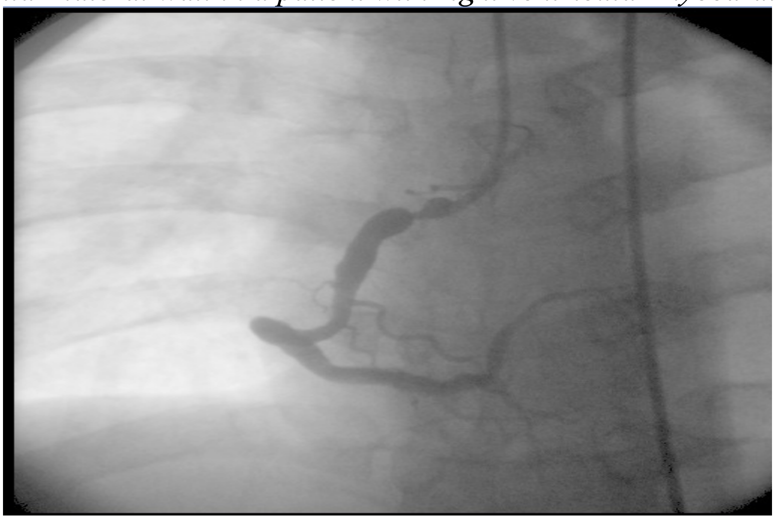


ECG with right sided chest leads

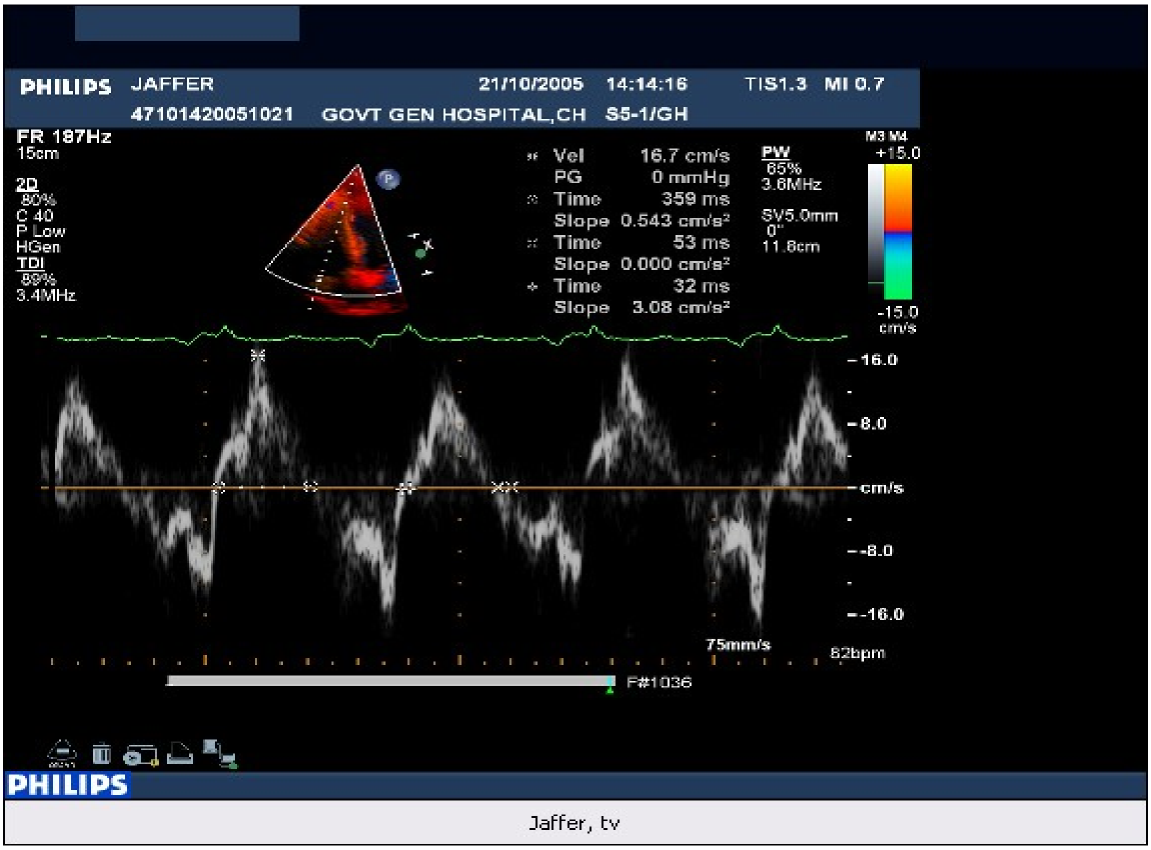




Pulse-wave tissue Doppler at the inferior aspect of the tricuspid annulus Showing systolic (Sm) and diastolic (Em and Am) myocardial velocities from right ventricular lateral wall in a patient with right ventricular myocardial infarction



Coronary angiogram showing proximal RCA lesion



Pulse-wave tissue Doppler at the inferior aspect of the tricuspid annulus showing systolic (Sm) and diastolic (Em and Am) myocardial velocities from right ventricular lateral wall in a patient with inferior wall myocardial infarction without RVMI .

Coronary angiogram showing normal proximal right coronary artery.

DISCUSSION

Right ventricular function is the prognostic predictor of numerous heart diseases, and it is affected especially by RVMI that accompanies inferior MI resulting from the occlusion of the right coronary artery[35,36.] RVMI impairs right ventricular function. However, it is difficult to assess both right ventricular anatomy and function with reliable conventional echocardiographic examination because of its complex structure. In most cases, the visual assessment of the right ventricular free wall by echocardiography leads to an underestimation of hypokinesia, due to an asymmetric contraction of the right ventricular walls toward its center. It has been suggested that color or pulsed-wave TDI, which is frequently used in assessing left ventricular function, also can be used to assess right ventricular function. The myocardial velocities obtained by pulsed-wave TDI from the right ventricular free wall at the level of the tricuspid annulus in the apical four-chamber view show the longitudinal dynamics of the right ventricle, which is not seen with visual scoring.

In studies assessing right ventricular function by using techniques other than TDI, the movement of the tricuspid annulus has been shown to represent the global right ventricular function. It has been documented that significant right coronary artery disease can be identified with the assessment of systolic velocity obtained by pulsed-wave TDI from the right ventricular free wall close to the tricuspid lateral annulus in the apical four-chamber view during dobutamine stress echocardiography[37,38,39,40,41.] Finally, it has been shown that tricuspid annulus systolic velocity decreases in patients with inferior MIs compared to those with anterior MIs, and in those with RVMIs compared to those without RVMIs. On the basis of the results of these studies, we studied the diagnostic value of the right ventricular free wall Sm in the identification of RVMI proximal right coronary artery disease. We found that the right ventricular free wall Sm and Em obtained from the right ventricular free wall was significantly lower in the patients in whom the IRA was the proximal right coronary artery than in those in whom the IRA was the distal right or circumflex coronary artery[42,43,44]

The decreased Sm of the right ventricular free wall can be accepted as an indicator of right ventricular systolic dysfunction, consequent to RVMIs. Also, a decrease in the Em of the right ventricular free wall shows the development of right ventricular diastolic dysfunction in those with RVMIs and in those who experienced MIs due to a proximal right coronary artery lesion. An Sm of < 12 cm/s showed RVMIs with high sensitivity (83%) and specificity (93%). In addition, the negative predictive value was also high (90%).

The MPI was defined as a noninvasive Doppler measurement of ventricular function. The MPI, also known as the Tei index, is commonly used in the assessment of systolic and diastolic function of the left ventricle. It has been reported that the MPI obtained by the combination of systolic and diastolic time intervals can be used in the determination of the degree of dysfunction in patients with left ventricular dysfunction, and it correlates with conventional parameters such as left ventricular ejection fraction and invasive measurements[45.] It also has been shown that this index is a simple and useful method that is independent of heart rate and is unaffected by the geometric shape of the ventricle, with excellent reproducibility between observers. Tei et al have shown that the right ventricular MPI is increased (0.93) in patients with primary pulmonary hypertension, and it is the most important indicator in discriminating healthy subjects. Eidem et al also have shown that the MPI increases significantly (0.63) in subjects with severe right ventricular insufficiency and

Ebstein anomaly. We considered calculating the MPI with TDI. We detected that the MPI that was calculated with this method was significantly higher in patients with RVMIs in whom the IRA was the proximal right coronary artery. A right ventricular MPI of > 0.70 correlates with the identification of RVMI and proximal right coronary artery disease. In 14 of 18 patients with RVMIs and in whom the IRA was the proximal right coronary artery, the MPI was > 0.70, whereas in 29 of 32 patients without RVMIs in whom the IRA was the distal right or circumflex coronary artery it was ≤0.70. These findings have demonstrated that an MPI of > 0.70 may diagnose RVMI and proximal right coronary artery disease with high sensitivity and specificity.

The early diagnosis of RVMI still has been suboptimal. Although the clinical triad of hypotension, absence of pulmonary congestion, and elevated jugular venous pressure is quite specific, the sensitivity is only 10 to 25%. At the present time, even when using additional chest leads, electrocardiography, which is the most common modality used for the diagnosis of RVMI, remains insufficient when compared with autopsy-proven MI. RVMI resulting from the occlusion of the proximal right coronary artery leads to pandiastolic dysfunction as well as to right ventricular systolic dysfunction. The Tissue Doppler Imaging method assessing myocardial function impairment is a new diagnostic tool that can be used to detect the IRA localization in patients with acute inferior MIs. The right ventricular free wall Sm and MPI values obtained by this method can give correct and reliable information about the severity of disease and the localization of the lesion, as well as the diagnosis.

Limitations of the Study

While most of the studies, applying pulsed TD for the investigation of RV function appear very encouraging, it is fair to state that even the TD evaluation of RV tricuspid annular motion has a potential limitation.

In tissue Doppler we can measure several velocities in several directions. In the cardiac motion there are translational, rotational and deformational movements. Besides many tissues near the heart move due to transmitted cardiac motion, vessel pulsation, respiratory motion and involuntary muscle movements and these interact with cardiac motion further and cause false Doppler shifts. Doppler interrogations at one point will determine the velocity of the resultant of all these movements projected in the line of the Doppler beam with angle correction. Similarly at a particular point there are movements in several axes and we can never predict the sum resultant vector. Even if known, the resultant is accurately recorded only if it is the line of the Doppler beam.[46] It could consequently produce controversial findings the inaccuracy of which is proportional to the angle occurring between the transducer and the annular point of the same tricuspid motion.

With regard to this aspect, a good point in favour of Tissue Doppler is, however, that the function of the right ventricle is mainly dependent on its contraction and relaxation along the long axis. [47]

The parameters obtained by TDI provide quantitative data, which can give us an idea about the extent of the RVMI as well diagnosing it. But a correlation of these data with autopsy findings that can be accepted as the only ‘ gold standard” is needed. Future studies should be addressed towards the longitudinal follow-up of TD RV patterns to the determination of the progression from early RV wall dysfunction until the evidence of RV global failure.

CONCLUSION

- **The right ventricular systolic velocity (tricuspid annular velocity) obtained from the free wall decreases and the right ventricular myocardial performance index increases in patients with Right ventricular myocardial infarction.**

- **The Right ventricular myocardial infarction in the presence of inferior wall MI could be diagnosed and infarct related artery could be predicted correctly by the use of these parameters, which are easily obtained by Tissue Doppler Imaging method.**

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